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RECREATIONAL LAKES PROGRAM

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THE  
ONTARIO WATER RESOURCES COMMISSION

REPORT  
ON WATER QUALITY  
IN  
STURGEON LAKE

1971

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## SUMMARY

A study to evaluate the status of water quality in Sturgeon Lake was carried out during the summer of 1971.

Sturgeon Lake lies in the Trenton Bedrock Formation which is a flat limestone bedrock buried beneath a deep mantle of different textured materials providing good local drainage. Most of the north shoreline of the lake has over 2 meters (7 feet) of overburden while the rest of the shoreline generally has a thin cover ranging from bare rock to one meter in depth. The shoreline is composed of a variety of top soils ranging from fine sandy to coarse gravelly loams with black muck in the lower plains. Generally, the depth of the soils, excluding those along the north shore, can be considered as unsuitable for cottage development utilizing standard subsurface septic tank systems.

In June and August, water temperatures were lower in the deeper layers of Sturgeon Lake than in the upper strata at all mid-lake stations. During these periods, low deep-water dissolved oxygen concentrations and high carbon dioxide levels resulting from decomposition of organic matter were observed. In July and September, uniform temperature and dissolved oxygen regimes were apparent throughout the lake indicating the effect of vertical mixing processes.

pH values at stations located in the southern and northeastern sections of the lake were higher than those recorded from sampling sites located in the northwestern section of the lake. In fact, during the August survey, values recorded near the Village of Bobcaygeon exceeded the criteria for public surface water supplies and recreational use. These high pH values resulted from the photosynthetic activity of excessive algal densities.

Total alkalinity and hardness concentrations indicated that moderately hard water conditions prevailed in the lake.

The enriched nature of the lake was revealed by relatively high mean values for total Kjeldahl nitrogen (0.47 mg/l) and total phosphorus (0.029 mg/l), two nutrients critical for aquatic plant and algal growth. Higher levels of both nutrients were recorded in the southern and eastern areas of the lake than near Fenelon Falls, indicating an enriching effect from agricultural runoff, Lake Scugog and from the municipal waste discharges at Lindsay.

Algal levels as measured by chlorophyll a concentrations were extremely high during August and September. Such high levels significantly reduced the water quality for most water-oriented recreational activities and diminished the aesthetic quality of the lake. In view of the high nutrient and chlorophyll concentrations, every effort should be made to prevent any direct flow or leachate from domestic waste disposal systems or other potential sources of pollution from gaining access to the lake.

Sturgeon Lake was generally well within the OWRC bacteriological criteria for recreational use. The bacterial levels were higher in June than during the other two surveys which was attributed to contamination being carried into the lake by the June rainfall. In June and August, stations adjacent to the heavily-developed shoreline contained higher bacterial levels than the mid-lake stations, suggesting a bacterial input from domestic waste disposal systems.

## INTRODUCTION

Maintenance of good water quality in recreational lakes in the Province of Ontario is of vital concern to the Ontario Ministry of the Environment and other governmental agencies involved in tourism and the control and management of shoreline development of cottages and resorts. In 1970 an interdepartmental program was established to survey a number of recreational lakes in order to detect and correct sources of water pollution and ensure that our lakes would be well managed to protect water quality. The Ontario Department of Health, whose jurisdiction in this program was transferred to the Ministry of the Environment, would carry out on-shore inspection and correction of faulty private waste disposal systems, whereas the Ontario Water Resources Commission (now within the Ministry of the Environment) would evaluate the existing water quality of the respective lakes. A record of the present status of the private waste disposal systems and the lake water quality would also be documented for comparative use in any future studies and some data from the first year are included in this report.

Recreational lakes are subjected to two major types of water quality impairment; bacteriological contamination and excessive growths of algae and aquatic weeds (eutrophication). The two problems may result from a common source of wastes but the consequences of each are quite different. Bacteriological contamination by raw or inadequately treated sewage poses an immediate public health hazard if the water is used for bathing. In order for this to occur, raw or inadequately treated wastes or septic tank effluents must gain entry to the lake although it may not be obvious

upon visual inspection of the site. It must be noted that no surface water is considered safe for human consumption without prior treatment including disinfection. The algae and weed growths impair aesthetic values and recreational use of a lake but seldom pose a health hazard.

In order to carry out its responsibility of evaluating the status of water quality in recreational lakes, the Ontario Water Resources Commission undertook a study on Sturgeon Lake in the summer of 1971. This study included the assessment of the lake with stress being placed on the bacteriological and nutrient enrichment problems.

Physical, chemical and biological surveys were conducted from June 22 to 24, from July 21 to 22, August 19 and from September 28 to 29.

Three bacteriological surveys were conducted; a spring survey from June 24 to 28, a mid-summer survey from August 6 to 16 and a fall survey from September 16 to 20 inclusive. Sampling each day for a minimum of five days is mandatory for a reliable assessment of bacteriological conditions.

In addition to the results obtained from these studies, information from other governmental agencies has been incorporated in this report which is the Ontario Water Resources Commission's contribution to the Interdepartmental Task Force Report which will deal with the overall cottage pollution program in Ontario.

The "Kawartha Lakes Water Management Study" was also initiated in 1971 to examine the complex problems of eutrophication which exist in the Kawartha Lakes including Sturgeon Lake. The broad objective of this

study is to develop a water management plan to protect and develop the recreational potential of the watershed. Included in this study are programs to evaluate the trophic status of the lakes, the sources of nutrients to the lakes, the nutrient cycling system within the lakes and the specific effects on the water environment of various wastewater inputs. An experiment is also planned to evaluate weed harvesting, both as a method of enhancing the recreational use of a lake and of providing a nutrient drain that could significantly reduce the quantity of nutrients available for plant growth in the future. As part of this experiment, effects of weed harvesting on the sport fisheries is being evaluated by biologists of the Department of Lands and Forests (now within the Ministry of Natural Resources). The study is expected to continue for at least three years.

A joint federal-provincial study committee (CORTS) has recently released a report entitled "The Rideau-Trent-Severn - Yesterday Today Tomorrow" which considers optimum recreational development of the Rideau-Trent-Severn waterway corridor which includes part of the Kawartha Lakes. Water and other environmental pollution problems received the highest priority in the list of recommendations in this report which was started in 1967. Other recommendations were made dealing with the use of open space, historical preservation and interpretation, public use areas and other topics designed to develop the corridor as a recreation resource. Many of the recommendations of this report have already been implemented by various federal and provincial agencies such as nutrient budget studies and correction of industrial waste discharges to the waterway.

## AREA DESCRIPTION

### Geography and Topography

Sturgeon Lake is located in the Townships of Fenelon and Verulam, Victoria County and spans the area between the villages of Fenelon Falls and Bobcaygeon and the Town of Lindsay (Figure 1).

The lake is "Y" shaped with a surface area of 43 square kilometers (16.5 square miles) and a shoreline length of 86 kilometers (53 miles). Except for the marshy areas, the water depth drops sharply to about 7 meters (23 feet) close to the shore. The lake bottom then flattens out, averaging about 8 meters (26 feet) in depth, with a maximum depth of 9 meters (30 feet).

The immediate watershed of the lake, excluding the waters from Lake Scugog and Cameron Lake, consists of 500 square kilometers (190 square miles) of land dominated by rolling hills. Most of the surrounding land is characterized by a loam type soil belonging to the Otonabee, Farmington and Dummer series. The remainder of the land belongs to the Cramahe Gravel, Muck and Marsh soil series (Figure 2). The most predominant soil is the Otonabee series which is a well-drained, sandy loam textured glacial till, containing a moderate amount of stone. This soil is calcareous since it is derived principally from limestone rock. The profile development shows some of the characteristics of both the Brown Forest Great Group and the Grey-Brown Podzolic Great Group. The Farmington series has a thin, moderately stony, glacial till covering limestone bedrock. The Dummer series is a very stony, calcareous, gravelly loam till with good drainage. The profile is thin and is characteristic of the Brown Forest soils of Ontario. The Cramahe Gravel series is generally found in long ridges known as eskers. The soil consists of coarse, calcareous sand and gravel and large boulders with good drainage. The Marsh series is low-lying land which is under



FIGURE - 1

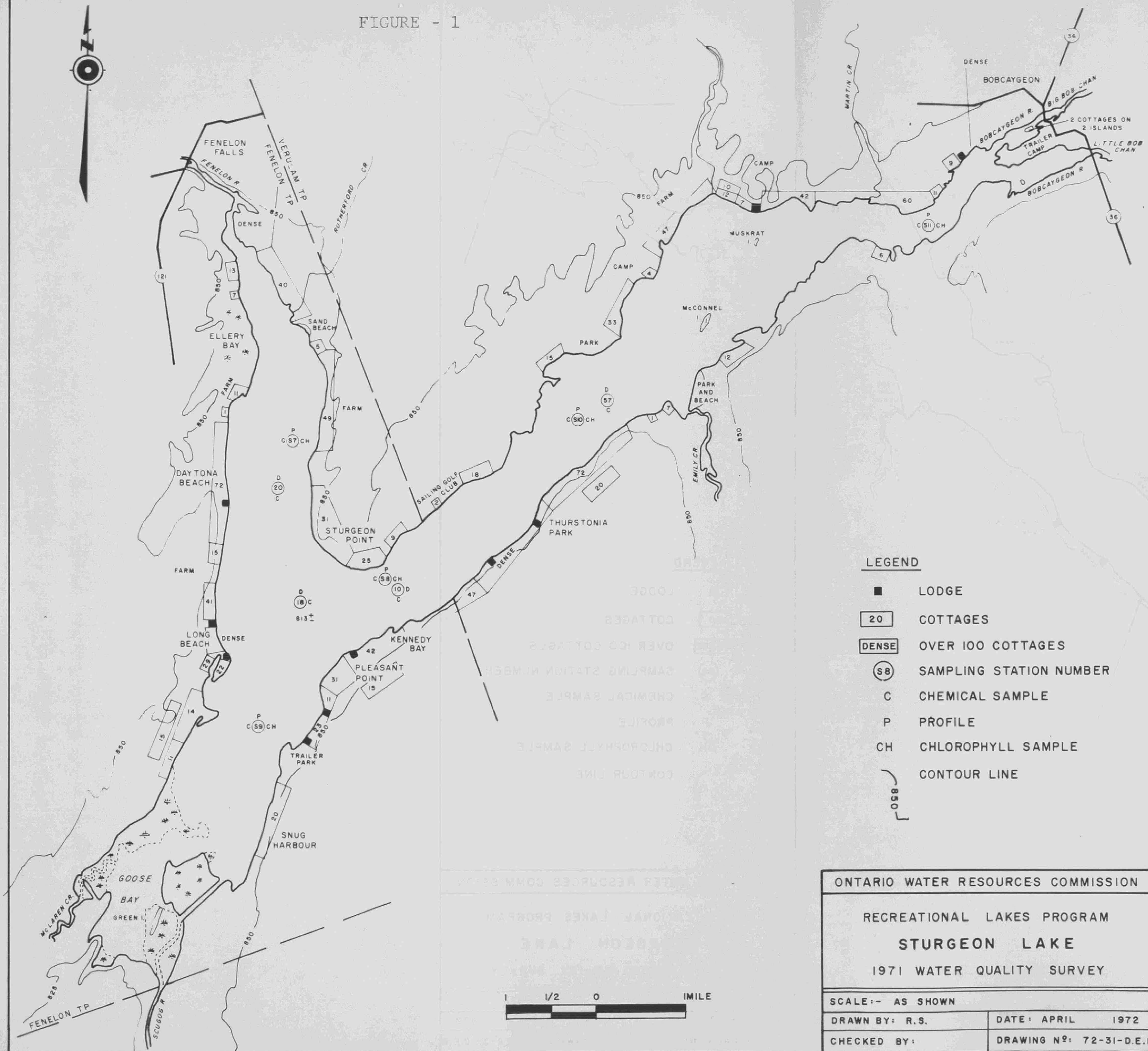
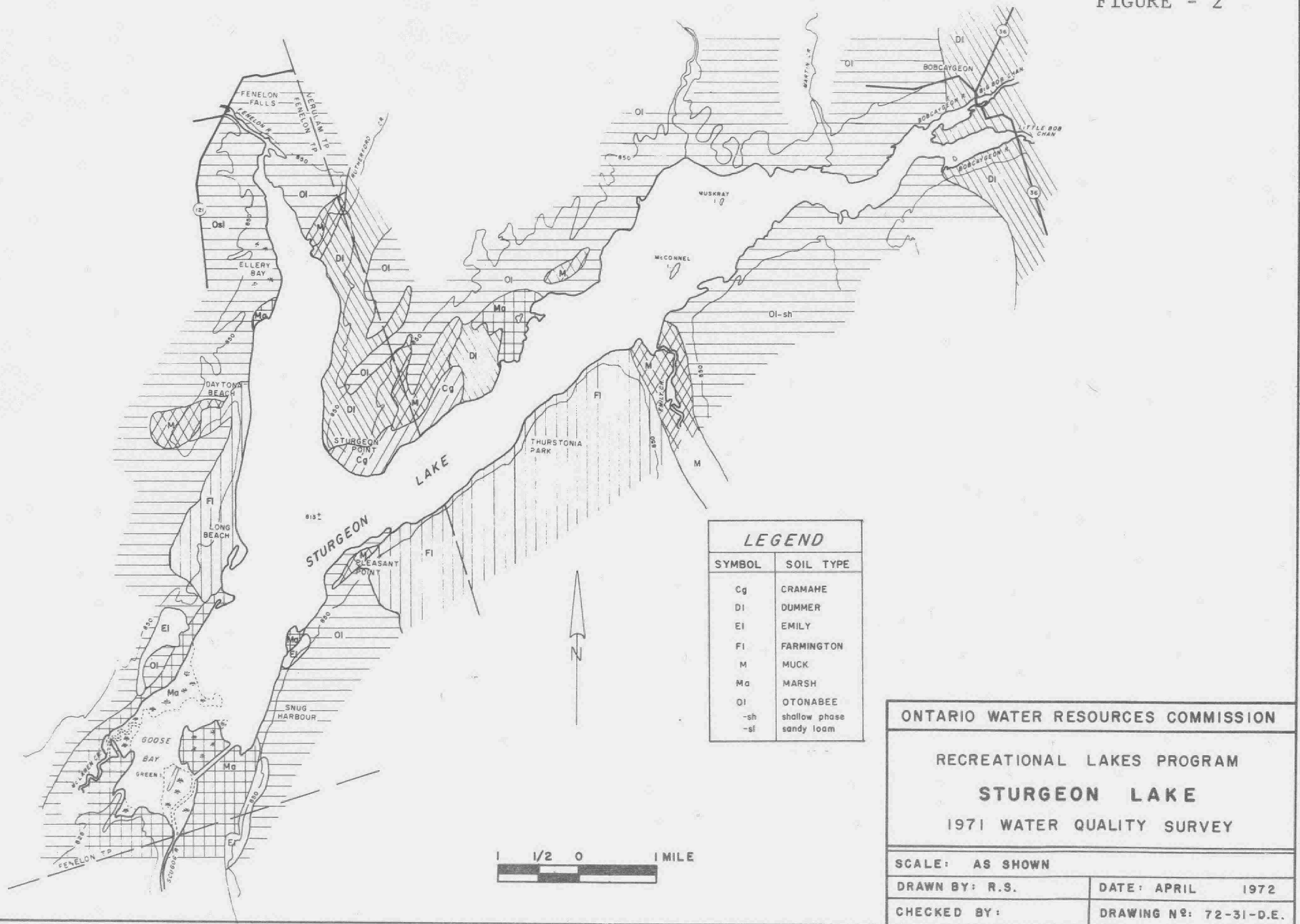


FIGURE - 2



water most of the year, while the Muck series is made up of organic deposits found in depressional areas.

#### Climatic Range

The area has a mean daily temperature of  $-8^{\circ}\text{C}$  ( $17^{\circ}\text{F}$ ) in January and a mean temperature of  $20^{\circ}\text{C}$  ( $68^{\circ}\text{F}$ ) in July. The mean annual precipitation is 80 centimeters (32 inches) including 200 centimeters (78 inches) of snow. According to meteorological reports, the area enjoys about 240 days yearly of no measurable precipitation. The summer climate is conducive to most recreational activities and the winter, with its abundance of snow early in the season provides for participation in most winter sports.

#### Water Movement

Sturgeon Lake is part of the Bay of Quinte Terminal Drainage Basin. It is a part of the Kawartha Lakes which serve as great reservoirs for the Trent River System. The waters of the system enter the lake at its north-west end via the Fenelon River and leave at its north-east end via Little Bob and Big Bob channels. The lake's other inflows are the Scugog River at its south tip and Emily Creek on the south shore of the north-west arm of the lake. Both of these inflows are swampy and slow moving. The two locks situated at the north-west and north-east end of the lakes are operated by the Federal Ministry of Transport Canals Division, Trent Canal System. The lock at Fenelon Falls has a drop of 7 meters (23 feet) and the lock at Bobcaygeon has a drop of 2 meters (6 feet).

#### Shoreline Development

The shoreline of Sturgeon Lake is well developed with approximately 2,000 cottages on it. The areas with dense development are at: Bobcaygeon,

Fenelon Falls, Long Beach, Sturgeon Point and Thurstonia Park.

#### Water Usage

The lake supports recreational water sports such as fishing, boating, water skiing and swimming. Fishing for bass, pickerel and maskinonge is reasonably good.

The majority of cottage owners and the Village of Bobcaygeon use the lake as their source of domestic water supply. Bobcaygeon takes its water above the dam in Big Bob Channel. The village has a 910 kiloliter (200,000 gallons) per day capacity treatment plant with plant storage amounting to 240 kiloliter (53,000 gallons). At the present time the treatment plant serves only the south section of the village while the north section is served by a spring supply, feeding street-side taps by gravity. Expansion of the plant to serve the north section, is still under consideration.

An Ontario Water Resources Commission's "Water Pollution Survey of the Village of Fenelon Falls", conducted in 1971 disclosed that inadequately treated sanitary and industrial wastes have access to the local creek, the Fenelon River and the Trent Canal. At the present time the village has private sewage disposal systems but due to the geological conditions and the limited sized lots in the business section, the provision of adequate systems has been difficult. A sewage works program is under consideration and is currently in the final design stage.

The Town of Lindsay has a municipal sewage works consisting of collector sewers and a 6-celled, 109 acre, waste stabilization lagoon which has a rated capacity to serve 10,900 persons based on the design criteria of 100

persons per acre of lagoon area. In 1971, the calculated average sewage flow to the lagoon was 1.42 MGD. The lagoon has a continual discharge to a swampy area which drains to the Scugog River. The lagoon is operating at or close to design capacity and the degree of treatment obtained is generally representative of other similar installations in the Province. The town has authorized an engineering study related to expansion of the facilities to meet future needs. Such expansion will incorporate special facilities to improve phosphorus removal to meet the requirement of at least 80% phosphorus removal by the end of 1973.

The residents on Sturgeon Lake are provided with two municipal solid waste disposal sites located within a mile from the lake. The site located outside Fenelon Falls on Lot 22, Concession XI, Township of Fenelon is to be closed in the spring of 1972 and reopened on Lot 31, Concession II, Township of Verulam. The other site is located on Lot 13, Concession XI, Township of Fenelon. A new site to be opened is located on the west half of Lot 8, Concession IX, Township of Verulam.

Sturgeon Lake is part of the Trent Canal System and according to the Department of Tourism and Information, 18,516 boats used the system in 1969. Boaters spent an estimated \$8.6 million and an additional \$3.6 million was spent by the Federal Department of Transport for operation, maintenance and capital expenditure. Thus, \$12.2 million was injected into the economy of those areas adjacent to the Trent Canal in 1969.

## FIELD AND LABORATORY METHODS

### Physical, Chemical and Biological Field Methods

In selecting the physical, chemical and biological sampling sites on Sturgeon Lake an endeavour was made to choose the deepest locations. As well, a sufficient number of additional stations were sampled to represent adequately the entire lake (Figure 1.).

Temperature profiles were determined at each station using a telethermometer. Dissolved oxygen levels were measured using the alkalide azide modification of the Winkler method (Standard Methods 13th Edition). Additionally, samples for pH, total alkalinity and free carbon dioxide were collected 1m below the surface and 1m above bottom using a Van Dorn water sampler. The total alkalinity and free carbon dioxide concentrations were determined titrimetrically at the mobile laboratory located at Trent University, Peterborough.

At each station, two 32-ounce samples were collected using a composite sampler lowered through the euphotic zone (2x Secchi disc) or lowered to 1m above bottom whichever was less. One sample, for chlorophyll analysis, was immediately preserved with 10 - 15 drops of 2%  $\text{MgCO}_3$  suspension. The second was divided into two sub-samples; the first sub-sample was frozen for phosphorus and nitrogen analyses, and the second was refrigerated and subsequently analyzed for iron and hardness. In addition when the euphotic zone did not extend to the bottom, samples were collected from 1m above the sediment using a Van Dorn sampler and submitted for phosphorus, nitrogen, iron and hardness analyses.

## Physical, Chemical and Biological Laboratory Methods

All analyses were carried out using routine OWRC methods based on Standard Methods 13th Edition.

Iron was measured after the sample had been digested with acid to dissolve all forms of iron present.

Kjeldahl nitrogen and total phosphorus concentrations were determined after the sample was digested with acid and an oxidizing agent to destroy organic matter.

For chlorophyll determinations, 1 liter samples were filtered through a 1.2  $\mu$  membrane filter which was then extracted with 90% acetone for 24 hours. Absorbance of the extract was determined at wavelengths from 600 to 750 m $\mu$  using a Unicam SP1800 ultra violet spectrophotometer. The concentrations of chlorophyll a were calculated using the equation given by Richards and Thompson (1952).

## Bacteriological Field and Laboratory Methods

Five-day intensive bacteriological surveys were completed on Sturgeon Lake during June and September, and one eleven-day survey during August. During the June and August surveys, 59 stations were sampled each day at a depth of 1 meter below the surface using sterile, autoclavable, polycarbonate, 250 ml bottles. Additional samples were collected at Stations 10D, 18D, 20D and 57D (Figure 5) one meter above the bottom using a modified "piggy-back" sampler and sterile 237 ml evacuated rubber air syringes. In the September survey, Stations 4, 7, 14, 17, 18, 25, 38, 44, 47, 50, 51 and 18D were eliminated due to a shortage of laboratory personnel. All samples were stored on ice and delivered to the mobile laboratory within two to six hours



and analyzed for total coliform, fecal coliform and fecal streptococcus using the membrane filtration (MF) technique (Standard Methods 13th Edition) except that m-Endo Agar Les (Difco) was used for total coliform and MacConkey membrane broth (Oxoid) was used for fecal coliform determinations. The total coliform (TC), fecal coliform (FC) and fecal streptococcus (FS) were used as "indicators" of fecal pollution. The "indicators" are normal flora of the large intestine, and are present in large numbers in the feces of man and animals. When water is polluted with fecal material, there is a potential danger that pathogens or disease causing microorganisms may also be present.

The coliform group is defined, according to Standard Methods 13th Edition, as "all of the aerobic and facultative anaerobic, gram-negative, non-sporeforming rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C" and, or "all organisms which produce a colony with a golden-green metallic sheen within 24 hours of incubation" using the MF technique. This definition includes, in addition to the intestinal forms of the Escherichia coli group, closely related bacteria of the genera Citrobacter and Enterobacter. The Enterobacter - Citrobacter groups are common in soil, but are also recovered in feces in small numbers and their presence in water may indicate soil runoff or, more important, less recent fecal pollution since these organisms tend to survive longer in water than do members of the Escherichia group, and even to multiply when suitable environmental conditions exist. A more specific test for coliforms of intestinal origin is the fecal coliform test, with incubation of the organisms at 44.5°C. Though by no means completely selective for Escherichia coli, this test has proved useful as an indicator of recent fecal pollution.

Fecal streptococci (or enterococci) are also valuable indicators



of recent fecal pollution. These organisms are large, ovoid gram-positive bacteria, occurring in chains. They are normal inhabitants of the large intestine of man and animals, and they generally do not multiply outside the body. In waters polluted with fecal material, fecal streptococci are usually found along with coliform bacteria, but in smaller numbers, although in some waters they may be found alone. Their presence, along with coliforms, indicates that at least a portion of the coliforms in the sample are of fecal origin.

#### Bacteriological Statistical Methods

Fluctuations in bacterial concentrations due to changing environmental conditions require that a great number of samples be taken to arrive at a mean value which is representative of a specific sample location or sampling area. The most appropriate mean for bacterial levels and this type of data is the geometric mean. The vast quantities of bacteriological data generated from these samples necessitated the development of additional statistical methods to summarize the mean results into a more concise presentation. The statistical methods used are based on the analysis of variance. The stations on a lake can be grouped, by this method, into areas or groups of stations within the same statistical bacterial level, without the bias normally associated with manual interpretation.

The analysis of variance is particularly effective where bacterial concentrations vary slightly throughout the lake. Areas or stations with only slight differences in bacterial concentration can be isolated. Areas or stations with statistically higher bacterial numbers reliably indicate an input.

The results from all the analyses were organized as replicates representing the stations during the survey period. All data were transformed to logarithms (base 10) and all further analyses were done using these transformed data. A geometric mean (the antilogarithm of the average of the logarithm) was calculated on each station and for each parameter. The validity of the analysis of variance program (ANOVA-CRE; Burger, 1972) was based on the assumptions that the variances of all the stations were similar (Bartlett's test was found to be non-significant and the data followed a normal distribution), so the analysis of variance (F-test; Sokal, 1969) was calculated for all the stations. If the F was significant, then the multiple-t test was used to help determine the stations which should be deleted from the overall group to yield a homogeneous group of stations. The withdrawn stations were regrouped with respect to geographic proximity and similar means. The calculations on all groups were repeated using the analysis of variance program until each discrete group was homogeneous. The homogeneous groups that were geographically isolated were compared by means of the Student-t test (using the log GM and S.E.) which indicated the statistical difference between these groups. The Student-t test was also used to compare the grouped bacteriological data from the three surveys.

## DISCUSSION OF RESULTS

### Temperature and Dissolved Oxygen

On Sturgeon Lake, five stations were established for measuring temperature and dissolved oxygen profiles (S-1, S-2, S-3, S-4 and S-5; Figure 1).

In June a rapid temperature and dissolved oxygen decline was evident in the bottom waters at Stations S-1, S-2 and S-4 (Figure 3a). The low oxygen levels resulted from bacterial oxidation of organic matter, biological respiration and chemical oxidation. Uniform profiles were observed at Stations S-3 and S-5. The former station was located in shallow water and therefore stratification was prevented by wind action. The latter sampling site was near Bobcaygeon, the outlet of Sturgeon Lake, and was affected by strong currents which inhibited the establishment of thermal zonation.

There was no thermal stratification or dissolved oxygen depletion observed at any station in July (Figure 3b).

During August, lower temperature readings and dissolved oxygen saturations were apparent in the bottom waters at Stations S-1, S-2, S-3 and S-4 (Figure 3c). These low oxygen levels resulted from bacterial oxidation of organic biological respiration and chemical oxidation.

In September, homogeneous oxygen conditions generally prevailed throughout the lake and water temperatures were considerably reduced in comparison to the early surveys indicating autumnal cooling of the lake (Figure 3d). However, a blue-green algal bloom developed during the latter part of August and

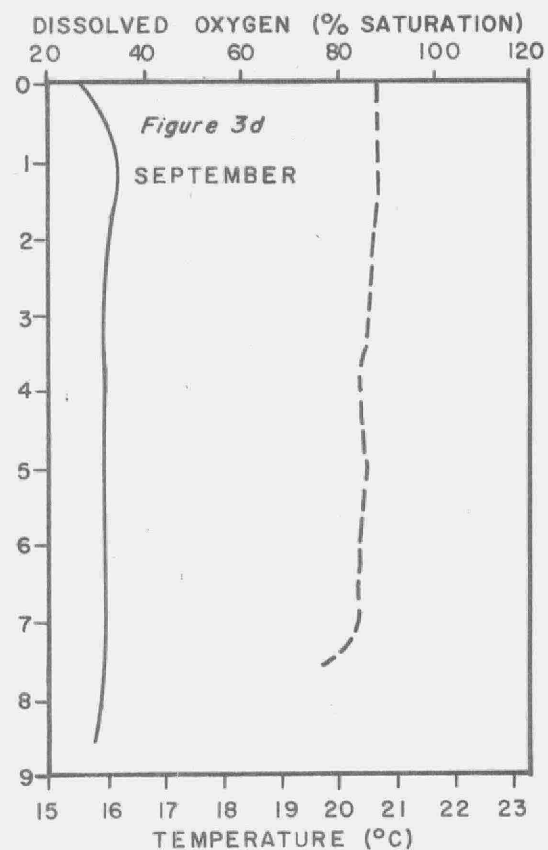
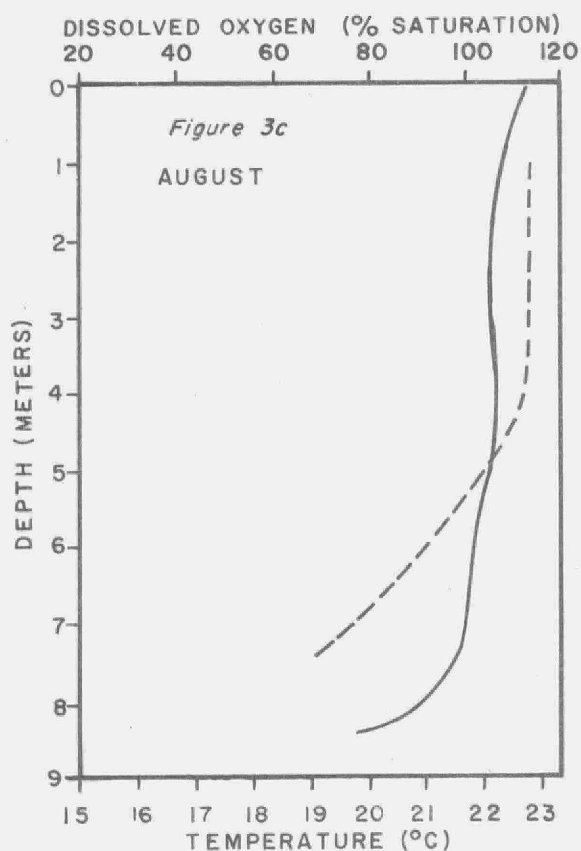
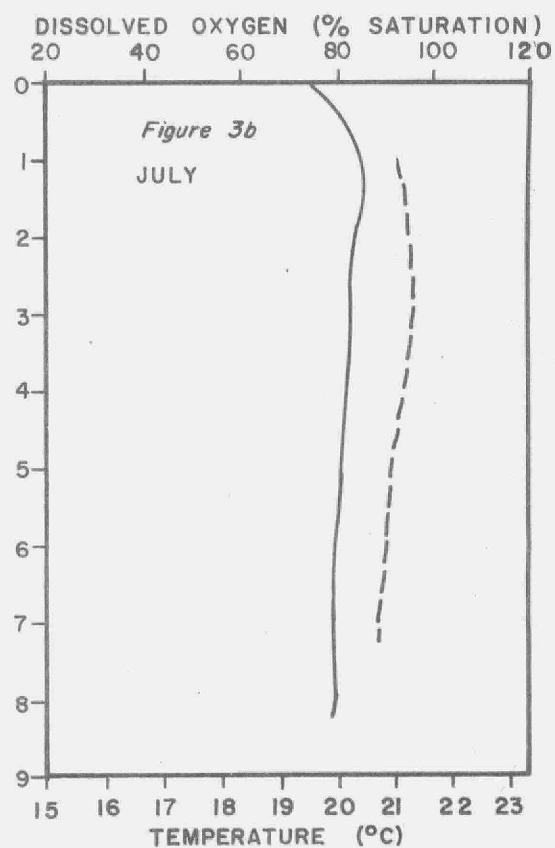
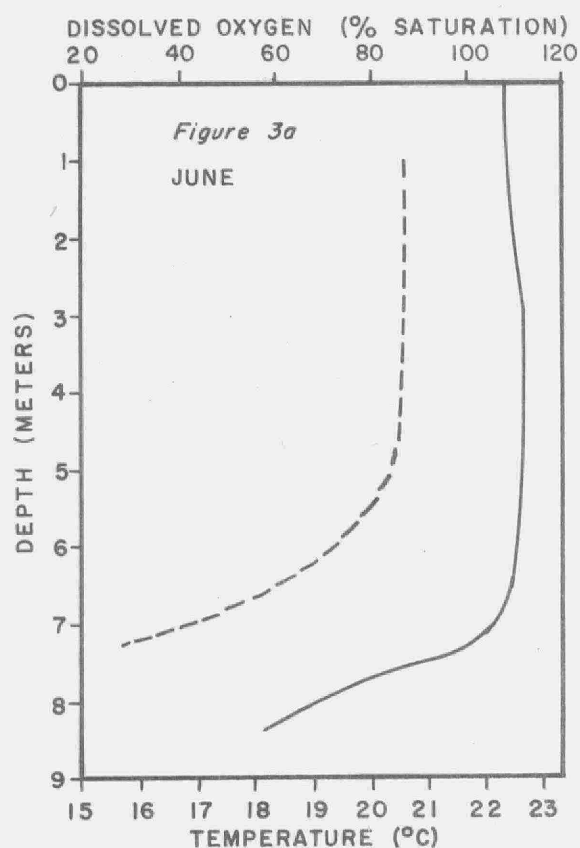


FIGURE 3. DISSOLVED OXYGEN AND TEMPERATURE PROFILES  
FOR STATION S-10 IN STURGEON LAKE.

— TEMPERATURE  
- - - DISSOLVED OXYGEN

September resulting in surface saturations of dissolved oxygen as high as 135%.

pH, Total Alkalinity, Hardness, Free Carbon Dioxide and Conductivity

pH readings increased uniformly downstream from S-3 through S-4 to S-5, particularly during the warm summer months. Generally, surface and bottom waters ranged from 7.3 to 8.4 and from 6.8 to 8.3 respectively (Table 1). However on August 19 at S-5, pH values reached 9.0 at the surface and 8.8 near the bottom. These high values which result from photosynthetic activity of algae are common in enriched hard-water lakes and exceeded the water quality criteria for public surface water supplies and recreational use (OWRC 1970).

Total alkalinity and hardness values ranged from 43 to 71 mg/l and from 56 to 82 mg/l respectively (Tables 1 and 2) and indicate moderately hard water quality conditions.

Surface water carbon dioxide levels in Sturgeon Lake were low throughout the year (Table 1). In general, concentrations were slightly higher in the deeper waters than in the surface strata. For example, at Station S-1 on August 19 at 1m of depth and 1m above the sediments values of 3.0 and 5.5 mg/l respectively, were measured. Surface values of 0.0 mg/l at S-3, S-4 and S-5 coincided with the peak period of algal photosynthesis in the lake.

The lake was characterized by moderately high conductivity readings which reached a maximum of  $295 \mu\text{mhos}/\text{cm}^3$  and averaged  $187 \mu\text{mhos}/\text{cm}^3$ . A decrease in conductivity was apparent in August.

## Iron

Euphotic zone and bottom iron concentrations ranged from 0.00 to 0.15 mg/l and 0.00 to 0.30 mg/l respectively.

## Total Kjeldahl Nitrogen and Total Phosphorus

Relatively high mean values for nitrogen (0.47 mg/l) and phosphorus (0.029 mg/l) for Sturgeon Lake reflect the enriched nature of the lake. A distinct increase in nutrient concentrations was apparent between Stations S-1 and S-2. This enriching effect was probably due to inputs from Lake Scugog, agricultural runoff and municipal waste discharges from Lindsay. For example, Stations S-2 to S-5 were characterized by nitrogen and phosphorus levels 2 to 3 times higher than those recorded at Station S-1.

Generally, troublesome levels of algae may appear when total phosphorus concentrations approximating 0.020 mg/l are attained. The mean total phosphorus concentration of 0.029 mg/l which exceeded this limit was consistent with the observed excessive aquatic plant and algal growths. Since the lake is naturally enriched, (Schenk, 1971) further inputs from municipal wastes, agricultural runoff, inflowing streams and from malfunctioning or improperly installed domestic waste disposal systems will serve to accelerate the process of eutrophication.

## Chlorophyll a

Algal levels as reflected by chlorophyll a concentrations were moderately high during the June and July surveys as values ranged from 1.6 to 5.9 ug/l. During August and September chlorophyll a concentrations were as high as 27.0 ug/l corresponding to an extensive bloom of blue-green algae. Such high

algal production severely reduces water quality for recreational activities such as swimming and water skiing and diminishes the aesthetic quality of the lake.

Water clarity, which is one of the more important parameters used in defining water quality, can be measured using a Secchi disc. Figure 4 presents a chlorophyll a - Secchi disc relationship for a number of surface waters and clarifies the "trophic status" of Sturgeon Lake relative to numerous other well known recreational lakes in the province (see Brown 1972 for derivation of chlorophyll a - Secchi disc relationship). The enriched status of Sturgeon Lake is indicated (Figure 4) by its proximity to values computed for the Bay of Quinte, the Western Basin of Lake Erie and Gravenhurst Bay; three eutrophic bodies of water.

FIGURE -4

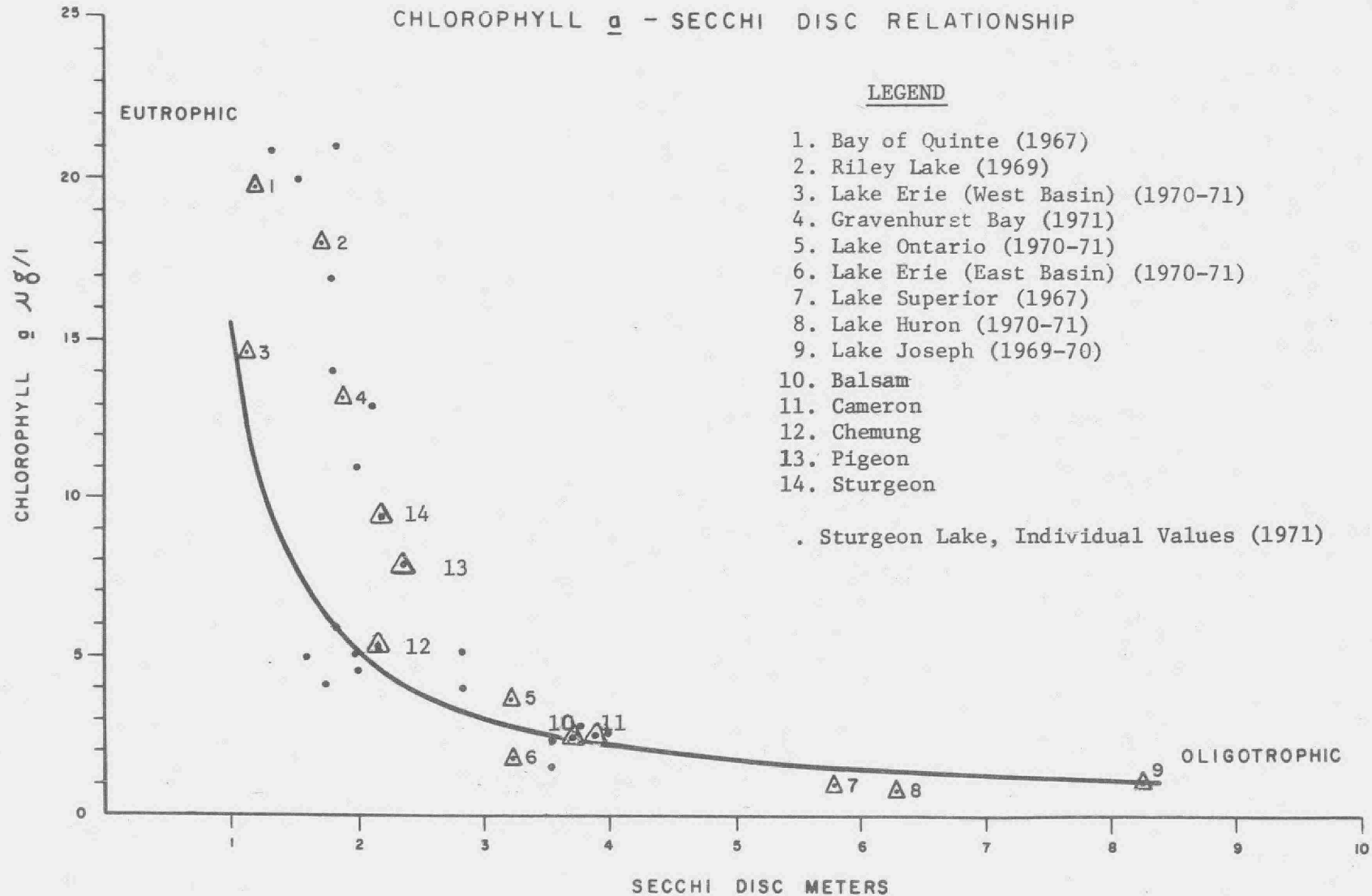


Figure 3 : The relationship between Chlorophyll a & Secchi disc as determined from the recreational lakes surveyed in 1971, as well as the individual Chlorophyll a - Secchi disc values for Sturgeon Lake. The Great Lakes values were added for comparative purposes.



## Bacteriology

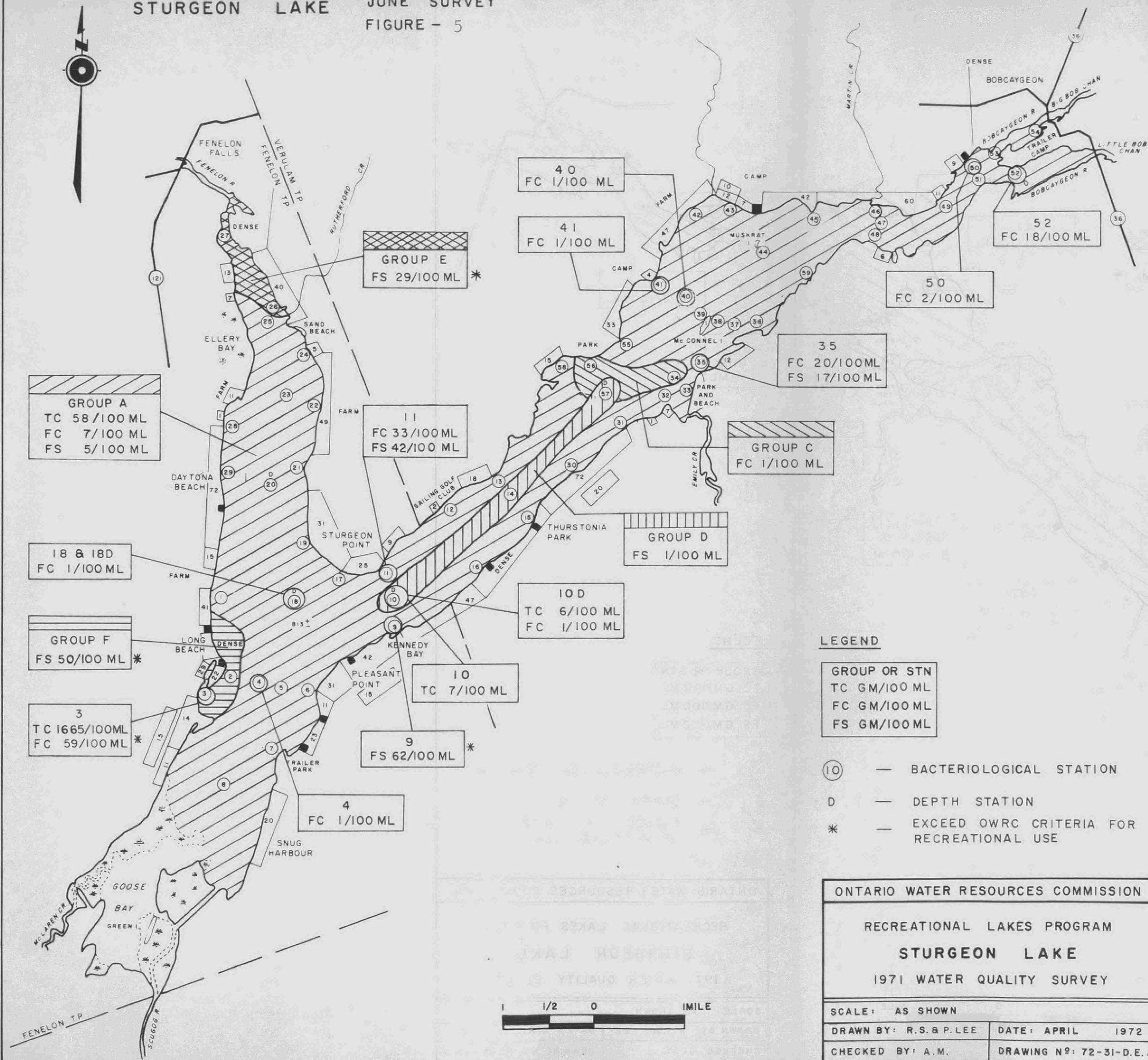
Sturgeon Lake, with few exceptions, was well within the OWRC criteria for total body contact recreational use (OWRC, 1970) during the three survey periods.

In June, the lake had overall TC, FC and FS means of 58/100 ml, 7/100 ml and 5/100 ml respectively (Group A, Figure 5). Group F (Stations 2 and 3), bordering a low, marshy shoreline, had an elevated FS mean of 50/100 ml (Table 5) exceeding the OWRC FS criteria. This high FS level has been attributed to runoff from the marsh following heavy rain on the first two days of the survey. The Lindsay Climatological station recorded 0.60 inches of rain on June 24 and 0.61 inches on June 25. Station 3, within Group F adjacent to a heavily cottaged shoreline area, had significantly higher bacterial levels of 1,665 TC/100 ml and 59 FC/100 ml. The TC numbers exceeded OWRC criteria for recreational use. Station 10, with 7 TC/100 ml and Station 10D with 6 TC/100 ml and 1 FC/100 ml were both significantly lower than Group A.

In June, Group C, with 1 FC/100 ml, split Group B, with 6 FC/100 ml from Group A. However, Groups A and B were not significantly different (student's  $t$ ,  $t = 0.356$ ; degrees of freedom,  $df = 212$ ).

Stations 4, 18, 18D, 40 and 41 all with geometric means of 1 FC/100 ml, Station 50 with 2 FC/100 ml, and Group D (Stations 10, 14, 57) with 1 FC/100 ml, had significantly lower bacterial levels than Groups A and B (Figure 5). Each of these was a mid-lake station far removed from any shoreline bacterial input. Station 9 (62 FS/100 ml), Station 11 (33 FC/100 ml and 42 FS/100 ml), Station 35 (20 FC/100 ml and 17 FS/100 ml) and Station 52 (18 FC/100 ml) all had bacterial levels significantly higher than the

# STURGEON LAKE JUNE SURVEY FIGURE - 5



## LEGEND

GROUP OR STN  
TC GM/100 ML  
FC GM/100 ML  
FS GM/100 ML

- ⑩ — BACTERIOLOGICAL STATION
- D — DEPTH STATION
- \* — EXCEED OWRC CRITERIA FOR RECREATIONAL USE

ONTARIO WATER RESOURCES COMMISSION

RECREATIONAL LAKES PROGRAM

STURGEON LAKE

1971 WATER QUALITY SURVEY

SCALE: AS SHOWN

DRAWN BY: R.S. & P. LEE

DATE: APRIL 1972

CHECKED BY: A.M.

DRAWING NO: 72-31-D.E.A

remainder of the lake. Each of these stations was located in an area of heavy population or recreational use. These higher bacterial levels were attributed to contaminated runoff following the heavy rainfall early in the survey. Group E, with 29 FS/100 ml, exceeding the OWRC FS criteria, indicated a possible bacterial input from the Fenelon River.

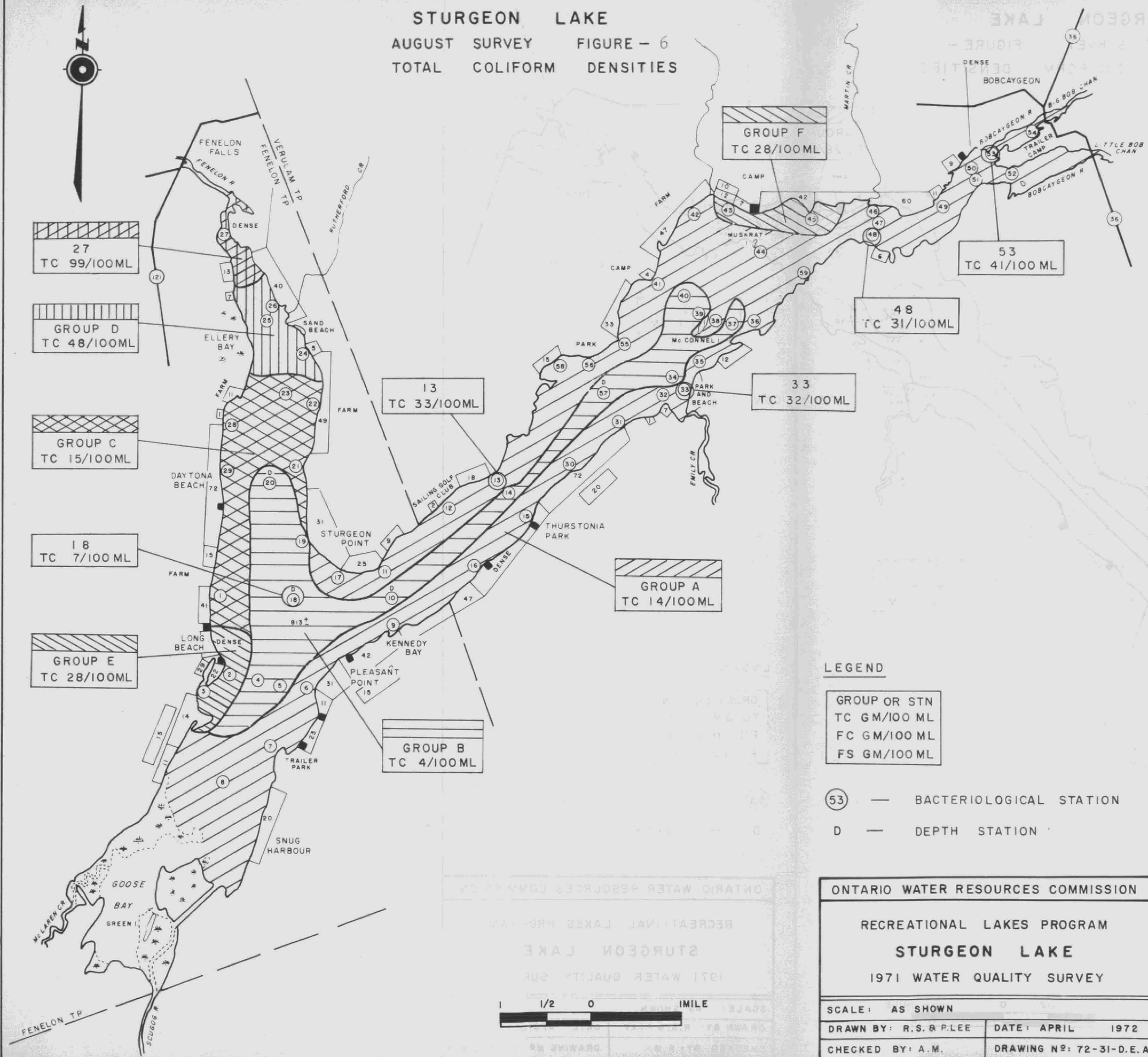
In the August survey, consistently high TC, FC and FS levels were observed at the northwest end of the lake and were attributed to a bacterial input from the Town of Fenelon Falls via the Fenelon River. This input was most evident at Station 27, immediately south of the inflow, and less evident with increasing distance from the town. Station 27 had the highest bacterial levels on the lake for all three parameters (Figures 6 & 7) with 99 TC/100 ml, 30 FC/100 ml and 22 FS/100 ml. Group D with 48 TC/100 ml and 6 FC/100 ml and Group J, which included Group D, with 4 FS/100 ml, were immediately downstream from Station 27 (Figures 6 & 7). The bacterial means for both groups were significantly lower than those of Station 27, but significantly higher than the main body of the lake.

The second trend evident in the August survey was that higher bacterial levels occurred at shoreline stations than at mid-lake stations. The most densely cottaged areas appeared to have the highest bacterial concentrations.

Group B, covering the mid-lake area, had the lowest TC level, at 4/100 ml. The majority of shoreline areas were included in two non-significantly different ( $t = 0.3544$ ,  $df = 317$ ) groups, A and C, with 14 TC/100 ml and 15 TC/100 ml respectively. Groups E and F, both with 28 TC/100 ml and Stations 48 (31 TC/100 ml) and 53 (41 TC/100 ml) were adjacent to heavily developed

# STURGEON LAKE

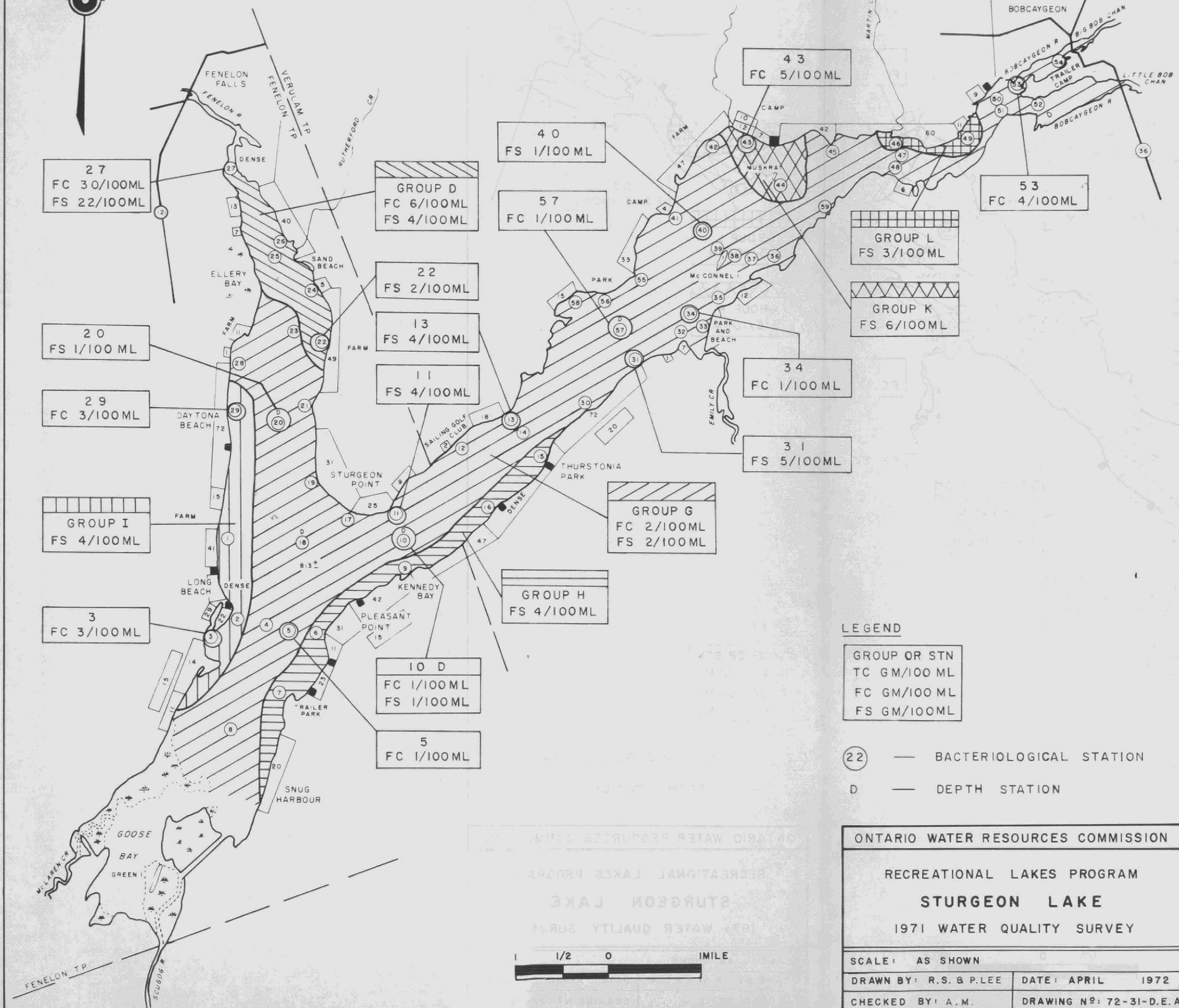
AUGUST SURVEY FIGURE - 6  
TOTAL COLIFORM DENSITIES





# STURGEON LAKE

AUGUST SURVEY FIGURE - 7  
FECAL COLIFORM & FECAL STREPTOCOCCUS DENSITIES



shoreline areas and exhibited even higher TC concentrations (Figure 6).

Station 33 had a TC level of 32/100 ml indicating a possible bacterial input from Emily Creek.

Although all the bacterial densities were low during the August survey, they do indicate an input from shoreline areas. The rapid demise of the enteric bacterial population upon entering the aquatic environment and the dissipation, and dilution of the remaining bacteria would account for these lower concentrations since the sample stations were located at least 50 feet from shore. It is likely that these enteric bacterial levels would have been much higher if rainfall induced runoff had occurred which would have aided in their movement from the shoreline. The Lindsay Climatological station recorded only 0.09 inches of rain during the entire August survey period.

Means of 2 FC/100 ml and 2 FS/100 ml were observed for the majority of lake stations in August (Group G, Figure 7). Shoreline Stations 3, 27, 29, 43 and 53 displayed significantly higher FC levels while shoreline groups H, I, K, L and Stations 11, 13 and 31 displayed significantly higher FS concentrations. The mid-lake Stations 5, 34 and 57 for FC and 10D, 20D and 40 for FS were significantly lower than Group G (Figure 7).

In the September survey, the majority of lake stations were included in Group A with 15 TC/100 ml, 1 FC/100 ml and 2 FS/100 ml (Tables 3, 4, 5, Figure 8). As in the previous surveys, the area within the influence of the Fenelon River had significantly higher TC, FC and FS means. Group B (Stations 24, 26, 27) had 102 TC/100 ml and 7 FC/100 ml and Group D (Stations 26, 27) had 12 FS/100 ml. Group C with 4 TC/100 ml and Station 40 with 3 TC/100 ml were both significantly lower than the main body of the

lake (Figure 8).

Generally, the bacterial levels in June were significantly higher than in August for all three parameters (Tables 7a, b, c). The higher concentrations in June have been attributed to a leaching out of domestic waste disposal systems and rainfall induced soil runoff. The Lindsay Climatological station recorded 1.57 inches of rain for June 24-28 but only .09 inches from August 6 to 16. The TC, FC, FS means in September were similar to those of the August survey.

During both the June and August surveys, Stations 2 and 3 showed significantly higher bacterial concentrations than the main body of the lake. In August, and to a lesser extent in June, the shoreline stations indicated bacterial inputs probably from waste disposal systems. In all three surveys, Station 3 and the area downstream from Fenelon Falls displayed significantly higher bacterial levels indicating constant bacterial inputs.

Although Sturgeon Lake was generally well within the criteria for recreational use, no surface water is considered potable without prior treatment, including disinfection. Particular attention should be given to water drawn within the influence of the Fenelon River.

There did not appear to be any measurable bacterial effect on Sturgeon Lake (Station 8) from the Lindsay sewage lagoon or Scugog River.

STURGEON LAKE  
SEPTEMBER SURVEY  
FIGURE - 8

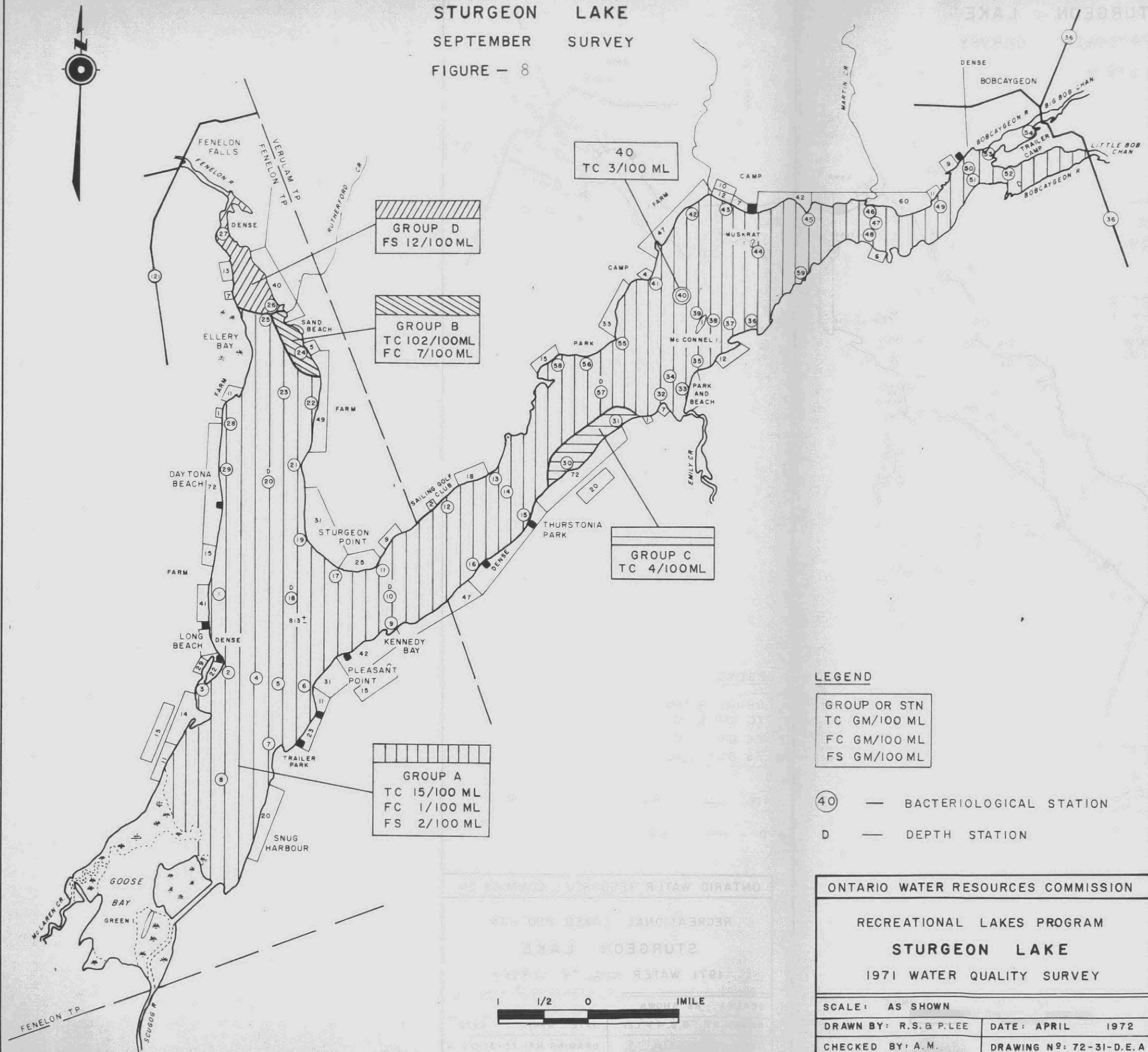




Table 1: Data ranges for temperature, dissolved oxygen, pH, carbon dioxide, total alkalinity and conductivity for stations S-7, S-8, S-9, S-10 and S-11 on Sturgeon Lake during the summer of 1971.

| Station | Sample Depth | Temperature<br>°C | D.O.<br>% Sat. | pH      | CO <sub>2</sub><br>mg/l | Alkalinity<br>mg/l | Conductivity<br>umhos/cm <sub>3</sub> |
|---------|--------------|-------------------|----------------|---------|-------------------------|--------------------|---------------------------------------|
| S-7     | 1m           | 16.1-23.4         | 82-102         | 7.3-7.7 | 2.4-4.2                 | 43-63              | 137-175                               |
|         | Bottom       | 16.1-19.0         | 41-101         | 7.2-7.7 | 1.7-7.3                 | 44-70              | 126-190                               |
| S-8     | 1m           | 16.6-22.6         | 85-105         | 7.3-8.0 | 3.1-3.6                 | 57-66              | 155-295                               |
|         | Bottom       | 16.4-20.8         | 0-93           | 6.8-7.8 | 1.1-6.2                 | 57-74              | 165-250                               |
| S-9     | 1m           | 15.2-22.9         | 80-115         | 7.5-8.3 | 0.0-3.5                 | 60-67              | 175-215                               |
|         | Bottom       | 15.1-22.9         | 79-115         | 7.6-8.3 | 0.0-2.9                 | 59-67              | 148-210                               |
| S-10    | 1m           | 16.2-22.4         | 89-116         | 7.4-8.4 | 0.0-3.5                 | 61-69              | 115-240                               |
|         | Bottom       | 16.0-22.2         | 29-88          | 7.3-8.0 | 1.2-5.4                 | 61-71              | 180-235                               |
| S-11    | 1m           | 16.1-23.9         | 88-135         | 7.8-9.0 | 0.0-1.6                 | 62-67              | 185-220                               |
|         | Bottom       | 16.0-23.8         | 90-130         | 7.7-8.8 | 0.0-1.8                 | 61-66              | 148-235                               |

Table 2: Data ranges for hardness, iron, total kjeldahl nitrogen, total phosphorus, chlorophyll a and Secchi disc for stations S-7, S-8, S-9, S-10 and S-11 on Sturgeon Lake during the summer of 1971.

| Station | Sample Depth | Hardness<br>mg/l | Iron<br>mg/l | TKN<br>mg N/l | Total-P<br>mg P/l | Chloro <u>a</u><br>ug/l | Secchi Disc<br>m |
|---------|--------------|------------------|--------------|---------------|-------------------|-------------------------|------------------|
| S-7     | Composite    | 56-72            | 0.0-0.15     | 0.25-0.40     | 0.015-0.026       | 1.6-5.2                 | 1.7-3.5          |
|         | Bottom       | 56-76            | 0.0-0.30     | 0.42-0.45     | 0.020-0.052       |                         |                  |
| S-8     | Composite    | 70-80            | 0.0-0.15     | 0.41-0.79     | 0.022-0.046       | 2.7-20.0                | 1.5-3.7          |
|         | Bottom       | 72-84            | 0.0-0.20     | 0.38-0.73     | 0.025-0.050       |                         |                  |
| S-9     | Composite    | 72-80            | 0.0-0.10     | 0.28-0.76     | 0.023-0.044       | 5.0-14.0                | 1.6-2.1          |
|         | Bottom       | 72               | 0.05         | 0.66          | 0.034             |                         |                  |
| S-10    | Composite    | 74-80            | 0.0-0.05     | 0.38-0.63     | 0.016-0.038       | 2.5-21.0                | 1.8-3.5          |
|         | Bottom       | 74-82            | 0.0-0.20     | 0.38-0.85     | 0.028-0.052       |                         |                  |
| S-11    | Composite    | 76-80            | 0.0-0.10     | 0.32-0.85     | 0.024-0.040       | 3.0-27.0                | 1.2-3.9          |
|         | Bottom       | 76-78            | 0.10-0.25    | 0.54-0.85     | 0.024-0.040       |                         |                  |

## EXPLANATION OF TERMS IN BACTERIOLOGICAL TABLES

|        |   |                                                                                                                                                                                                                                                    |
|--------|---|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| F      | - | the calculated analysis of variance statistic on F ratio.                                                                                                                                                                                          |
| df     | - | degrees of freedom of the F ratio for "between group" and "within group" variation.                                                                                                                                                                |
| F(5%)  | - | the F ratio from a statistics table (Rohlf 1969). If the calculated F is greater than the F(5%), a significant difference (SD) occurred between the groups in the analysis. If the F is less than F(5%), no significant difference (NSD) occurred. |
| log GM | - | the logarithm (base 10) of the geometric mean.                                                                                                                                                                                                     |
| S.E.   | - | the standard error of the log GM where                                                                                                                                                                                                             |

$$S.E. = \frac{s}{\sqrt{n}} \quad \text{and } s = \text{standard deviation}$$

|    |   |                                                                                                      |
|----|---|------------------------------------------------------------------------------------------------------|
| N  | - | the number of values in the mean.                                                                    |
| GM | - | the geometric mean of the bacterial level.                                                           |
| t  | - | the calculated test of significance or student t-test used to compare stations, groups and a survey. |

If t for the number of degrees of freedom shown is greater than the critical t value, a significant difference (SD) occurs.

SD refers to a significant difference at the .05 level but no significant difference at the .01 level.

SD\* refers to a significant difference at the .01 level but no significant difference at the .001 level.

SD\*\* refers to a significant difference at the .001 level.

TABLE 3

## Summary of the Analysis of Variance Grouping of Stations

Parameter - Total Coliform (TC)/100 ml

| SURVEY | JUNE 24 - 28                              | AUGUST 6 - 16                                                                                                         | SEPTEMBER 16 - 20                                        |
|--------|-------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|
| Group  | A<br>All stations<br>except<br>3, 10, 10D | A<br>Stations<br>6, 7, 8, 11,<br>12, 15, 17,<br>30-32, 35, 36,<br>38, 41, 42, 44,<br>46, 47, 49-52,<br>55, 56, 58, 59 | A<br>All stations<br>except<br>24, 26, 27, 30,<br>31, 40 |
| F      | .9913                                     | 1.427                                                                                                                 | 1.31                                                     |
| df     | 59, 190                                   | 26, 235                                                                                                               | 43, 147                                                  |
| F(.05) | 1.32                                      | 1.46                                                                                                                  | 1.39                                                     |
|        | NSD                                       | NSD                                                                                                                   | NSD                                                      |
| Log GM | 1.7605                                    | 1.151                                                                                                                 | 1.1704                                                   |
| SE     | .0441                                     | .0294                                                                                                                 | .0370                                                    |
| N      | 250                                       | 262                                                                                                                   | 191                                                      |
| GM     | 58                                        | 14                                                                                                                    | 15                                                       |
| Group  |                                           | B<br>Stations<br>4, 5, 10, 10D,<br>14, 18D, 19, 20,<br>20D, 34, 37, 39,<br>40, 57, 57D                                | B<br>Stations<br>24, 26, 27                              |
| F      |                                           | 1.633                                                                                                                 | 1.695                                                    |
| df     |                                           | 15, 146                                                                                                               | 2, 12                                                    |
| F(.05) |                                           | 1.75                                                                                                                  | 19.4                                                     |
|        |                                           | NSD                                                                                                                   | NSD                                                      |
| Log GM |                                           | .54421                                                                                                                | 2.0072                                                   |
| SE     |                                           | .0379                                                                                                                 | .0404                                                    |
| N      |                                           | 162                                                                                                                   | 15                                                       |
| GM     |                                           | 4                                                                                                                     | 102                                                      |
| Group  |                                           | C<br>Stations<br>1, 21-23, 28,<br>29                                                                                  | C<br>Stations<br>30, 31                                  |
| F      |                                           | 1.743                                                                                                                 | t = .4887                                                |
| df     |                                           | 5, 51                                                                                                                 | 7                                                        |
| F(.05) |                                           | 2.37                                                                                                                  | t(.05) = 2.365                                           |
|        |                                           | NSD                                                                                                                   | NSD                                                      |
| Log GM |                                           | 1.176                                                                                                                 | .5890                                                    |
| SE     |                                           | .068                                                                                                                  | .1549                                                    |
| N      |                                           | 57                                                                                                                    | 9                                                        |
| GM     |                                           | 15                                                                                                                    | 4                                                        |

Table 3 - continued

| SURVEY | JUNE 24 - 28 | AUGUST 6 - 16         | SEPTEMBER 16 - 20 |
|--------|--------------|-----------------------|-------------------|
| Group  |              | D<br>Stations 24 - 26 |                   |
| F      |              | 1.392                 |                   |
| df     |              | 2, 26                 |                   |
| F(.05) |              | 3.37                  |                   |
|        |              | NSD                   |                   |
| Log GM |              | 1.685                 |                   |
| SE     |              | .067                  |                   |
| N      |              | 29                    |                   |
| GM     |              | 48                    |                   |
| Group  |              | E<br>Stations 2, 3    |                   |
| F      |              | t = .3361             |                   |
| df     |              | 16                    |                   |
| F(.05) |              | t(.05) = 2.12         |                   |
|        |              | NSD                   |                   |
| Log GM |              | 1.446                 |                   |
| SE     |              | .105                  |                   |
| N      |              | 18                    |                   |
| GM     |              | 28                    |                   |
| Group  |              | F<br>Stations 43, 45  |                   |
| F      |              | t = .487              |                   |
| df     |              | 15                    |                   |
| F(.05) |              | t(.05) = 2.131        |                   |
|        |              | NSD                   |                   |
| Log GM |              | 1.449                 |                   |
| SE     |              | .1005                 |                   |
| N      |              | 17                    |                   |
| GM     |              | 28                    |                   |

TABLE 4

## Summary of the Analysis of Variance Grouping of Stations

Parameter - Fecal Coliform (FC)/100 ml

| SURVEY | JUNE 24 - 28 | AUGUST 6 - 16 | SEPTEMBER 16 - 20 |
|--------|--------------|---------------|-------------------|
|--------|--------------|---------------|-------------------|

| Group | A<br>Stations<br>1, 2, 5 - 10,<br>12 - 17, 19 - 33,<br>58, 20D, 57D | G<br>All Stations<br>except<br>3, 5, 10D, 24 -<br>27, 29, 34, 43,<br>53, 57 | A<br>All Stations<br>except<br>24, 26, 27 |
|-------|---------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------------------|
|-------|---------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------------------|

|        |         |         |         |
|--------|---------|---------|---------|
| F      | 1.114   | 1.3868  | 1.471   |
| df     | 31, 108 | 50, 475 | 45, 185 |
| F(.05) | 1.55    | 1.50    | 1.51    |
|        | NSD     | NSD     | NSD     |
| Log GM | .8205   | .2193   | .1632   |
| SE     | .0589   | .0151   | .0220   |
| N      | 140     | 525     | 231     |
| GM     | 7       | 2       | 1       |

| Group | B<br>Stations<br>36-39, 42-49,<br>51, 53, 55,<br>59 | D<br>Stations<br>24, 25, 26 | B<br>Stations<br>24, 26, 27 |
|-------|-----------------------------------------------------|-----------------------------|-----------------------------|
|-------|-----------------------------------------------------|-----------------------------|-----------------------------|

|        |        |       |       |
|--------|--------|-------|-------|
| F      | 1.48   | 1.52  | 1.11  |
| df     | 16, 57 | 2, 27 | 2, 12 |
| F(.05) | 1.84   | 4.21  | 19.4  |
|        | NSD    | NSD   | NSD   |
| Log GM | .7878  | .8098 | .8508 |
| SE     | .0598  | .0854 | .0751 |
| N      | 74     | 30    | 15    |
| GM     | 6      | 6     | 7     |

| Group | C<br>Stations<br>34, 56, 57 |
|-------|-----------------------------|
|-------|-----------------------------|

|        |       |
|--------|-------|
| F      | 0     |
| df     | 2, 10 |
| F(.05) | 4.96  |
|        | NSD   |
| Log GM | 0     |
| SE     | 0     |
| N      | 13    |
| GM     | 1     |

TABLE 5

## Summary of the Analysis of Variance Grouping of Stations

Parameter - Fecal Streptococcus (FS)/100 ml

| SURVEY | JUNE 24 - 28                                                         | AUGUST 6 - 16                                                                                                    | SEPTEMBER 16 - 20                     |
|--------|----------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|---------------------------------------|
| Group  | A<br>All Stations<br>except<br>2, 3, 9, 10,<br>11, 14, 14,<br>35, 37 | G<br>All Stations<br>except<br>1, 2, 3, 6,<br>7, 9, 10D, 11,<br>13, 15, 16, 20D,<br>22, 24-27, 29, 31,<br>40, 43 | A<br>All Stations<br>except<br>26, 27 |
| F      | 1.3289                                                               | 1.3809                                                                                                           | 1.503                                 |
| df     | 52, 166                                                              | 38, 368                                                                                                          | 47, 187                               |
| F(.05) | 1.35                                                                 | 1.39                                                                                                             | 1.51                                  |
|        | NSD                                                                  | NSD                                                                                                              | NSD                                   |
| Log GM | .7283                                                                | .2013                                                                                                            | .2291                                 |
| SE     | .0431                                                                | .016                                                                                                             | .0823                                 |
| N      | 219                                                                  | 407                                                                                                              | 235                                   |
| GM     | 5                                                                    | 2                                                                                                                | 2                                     |
| Group  | D<br>Stations<br>10, 14, 57                                          | H<br>Stations<br>6, 7, 9, 15, 16                                                                                 | D<br>Stations<br>26, 27               |
| F      | 0                                                                    | .9113                                                                                                            | t = .2714                             |
| df     | 2, 9                                                                 | 4, 50                                                                                                            | 8                                     |
| F(.05) | 4.26                                                                 | 2.61                                                                                                             | t(.05) = 2.306                        |
|        | NSD                                                                  | NSD                                                                                                              | NSD                                   |
| Log GM | 0                                                                    | .6014                                                                                                            | 1.0822                                |
| SE     | 0                                                                    | .068                                                                                                             | .2245                                 |
| N      | 12                                                                   | 55                                                                                                               | 10                                    |
| GM     | 1                                                                    | 4                                                                                                                | 12                                    |
| Group  | E<br>Stations<br>26, 27                                              | I<br>Stations<br>1, 2, 3, 29                                                                                     |                                       |
| F      | t = .1812                                                            | .6499                                                                                                            |                                       |
| df     | 4                                                                    | 3, 38                                                                                                            |                                       |
| F(.05) | t(.05) = 2.776                                                       | 2.84                                                                                                             |                                       |
|        | NSD                                                                  | NSD                                                                                                              |                                       |
| Log GM | 1.458                                                                | .6211                                                                                                            |                                       |
| SE     | 1.052                                                                | .0777                                                                                                            |                                       |
| N      | 6                                                                    | 42                                                                                                               |                                       |
| GM     | 29                                                                   | 4                                                                                                                |                                       |



Table 5 - continued

SURVEY      JUNE 24 - 28      AUGUST 6 - 16      SEPTEMBER 16 - 20

Group      F      J  
Stations      Stations  
2, 3      22, 24-26

F      t = .7724      .1315  
df      4      3, 36  
F(.05)      t(.05) = 2.776      2.84  
NSD      NSD  
Log GM      1.6967      .5450  
SE      .3432      .0663  
N      6      40  
GM      50      4

Group      L  
Stations  
43, 44

F      t = .194  
df      20  
F(.05)      t(.05) = 2.086  
NSD  
Log GM      .780  
SE      .120  
N      22  
GM      6

Group      L  
Stations  
46, 49

F      t = .3443  
df      20  
F(.05)      2.086  
NSD  
Log GM      .5106  
SE      .0985  
N      22  
GM      3

TABLE 6

Summary of t-tests Between Geographically Distinct Analysis of  
Variance Groupings Within a Survey

Parameter - Total coliform

SURVEY

AUGUST

|   | GROUP OR<br>STATION | GROUP B                                      | GROUP C                                     | GROUP D                                      |
|---|---------------------|----------------------------------------------|---------------------------------------------|----------------------------------------------|
| A | GROUP A             | t = 12.691<br>df = 422 SD**<br>t(.05) = 1.96 | t = .3544<br>df = 317 NSD<br>t(.05) = 1.96  | t = 5.856<br>df = 289 SD**<br>t(.05) = 1.96  |
|   | U                   | GROUP B                                      | -                                           |                                              |
|   | G                   |                                              | t = 8.363<br>df = 217 SD**<br>t(.05) = 1.96 | t = 12.131<br>df = 189 SD**<br>t(.05) = 1.96 |
| U | STATION             |                                              |                                             |                                              |
| S | 27                  | t = 9.367<br>df = 170 SD**<br>t(.05) = 1.96  | t = 4.855<br>df = 65 SD**<br>t(.05) = 2.00  | t = 2.387<br>df = 37 SD **<br>t(.05) = 2.021 |
| T |                     |                                              |                                             |                                              |

TABLE 7a

Summary of t-tests Between Analysis of Variance Groupings Between  
Surveys for Total Coliform

| SURVEY. |       | A U G U S T   |               |               |               |
|---------|-------|---------------|---------------|---------------|---------------|
|         | GROUP | A             | B             | C             | D             |
| J       |       |               | .             |               |               |
|         | A     | t = 11.535    | t = 19.273    | t = 5.92      | t = .5691     |
| U       |       | df = 510 SD** | df = 410 SD** | df = 305 SD** | df = 277 NSD  |
| N       |       | t(.05) = 1.96 | t(.05) = 1.96 | t(.05) = 1.96 | t(.05) = 1.96 |
| E       |       |               |               |               |               |

| SURVEY |       | A U G U S T   |               |               |                |
|--------|-------|---------------|---------------|---------------|----------------|
|        | GROUP | A             | B             | C             | D              |
| S      | A     | t = .6024     | t = 11.63     | t = .0714     | -              |
| E      |       | df = 451 NSD  | df = 351 SD** | df = 246 NSD  |                |
| P      |       | t(.05) = 1.96 | t(.05) = 1.96 | t(.05) = 1.96 |                |
| T      | B     | -             | -             | -             | t = 2.706      |
| E      |       |               |               |               | df = 42 SD**   |
| M      |       |               |               |               | t(.05) = 2.021 |
| B      |       |               |               |               |                |
| E      |       |               |               |               |                |
| R      |       |               |               |               |                |

TABLE 7b

Summary of t-tests Between Analysis of Variance Grouping Between Surveys  
for Fecal Coliform

| J U N E    S U R V E Y |                                             |                                             |
|------------------------|---------------------------------------------|---------------------------------------------|
| GROUP                  | A                                           | B                                           |
| G                      | t = 14.15<br>df = 663 SD**<br>t(.05) = 1.96 | t = 12.26<br>df = 597 SD**<br>t(.05) = 1.96 |

| A U G U S T    S U R V E Y |                                           |                                            |
|----------------------------|-------------------------------------------|--------------------------------------------|
| GROUP                      | G                                         | D                                          |
| A                          | t = 2.052<br>df = 754 SD<br>t(.05) = 1.96 | -                                          |
| B                          | -                                         | t = .2769<br>df = 43 NSD<br>t(.05) = 2.021 |

TABLE 7c

| J U N E    S U R V E Y |                                             |                                             |
|------------------------|---------------------------------------------|---------------------------------------------|
| GROUP                  | A                                           | B                                           |
| A                      | t = 12.08<br>df = 369 SD**<br>t(.05) = 1.96 | t = 11.87<br>df = 303 SD**<br>t(.05) = 1.96 |

## GLOSSARY OF TERMS

|                      |                                                                                                                                                                                                                                                                                                                                                                                                                         |
|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ALKALINITY           | :The alkalinity of a water sample is a measure of its capacity to neutralize acids. This capacity is due to carbonate, bicarbonate and hydrozide ions and is arbitrarily expressed as if all of the neutralizing capacity was due to calcium carbonate alone.                                                                                                                                                           |
| ANOXIC               | :Refers to conditions when no oxygen is present.                                                                                                                                                                                                                                                                                                                                                                        |
| BACKGROUND COLONIES  | :Background colonies are other lake water bacteria capable of growing on the total coliform plate, in spite of the inherent restrictive conditions.                                                                                                                                                                                                                                                                     |
| CHLORIDE             | :Chloride is simply a measure of the chloride ion concentration and is not a measure of chlorination.                                                                                                                                                                                                                                                                                                                   |
| CHLOROPHYLL <u>a</u> | :A green pigment in plants.                                                                                                                                                                                                                                                                                                                                                                                             |
| CONDUCTIVITY         | :Conductivity is a measure of the waters ability to conduct an electric current and is due to the presence of dissolved salts.                                                                                                                                                                                                                                                                                          |
| DIATOMS              | :Unicellular plants found on all continents and in all types of water where light and nutrients are sufficient to support photosynthesis. They are comprised of two siliceous frustules (cell walls) which have an outer valve (epitheca) fitting over the inner valve (hypotheca) like the lid on a box. The siliceous deposits comprising the frustules vary in regular patterns according to the individual species. |
| EPILIMNION           | :Is the thermally uniform layer of a lake lying above the thermocline. Diagram I.                                                                                                                                                                                                                                                                                                                                       |
| EUPHOTIC ZONE        | :The lighted region that extends vertically from the water surface to the level at which photosynthesis fails to occur due to insufficient light penetration.                                                                                                                                                                                                                                                           |
| EUTROPHIC            | :Waters containing advanced nutrient enrichment and characterized by a high rate of organic production.                                                                                                                                                                                                                                                                                                                 |

|                          |                                                                                                                                                                                                                                                                                                                                                                     |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| EUTROPHICATION           | :The process of becoming increasingly enriched in nutrients. It refers to the entire complex of changes which accompanies increasing nutrient enrichment. The result is the increased production of dense biological growths such as algae and aquatic weeds which generally degrade water quality and render the lake unsuitable for many recreational activities. |
| FECAL COLIFORMS (FC)     | :Fecal coliforms are bacteria associated with recent fecal pollution from man and animals.                                                                                                                                                                                                                                                                          |
| FECAL STREPTOCOCCUS (FS) | :Fecal streptococcus are bacteria associated with fecal pollution from animals and to a lesser extent man.                                                                                                                                                                                                                                                          |
| HARDNESS                 | :Hardness of water is a measure of the total concentration of calcium and magnesium ions expressed as if all of the ions were calcium carbonate.                                                                                                                                                                                                                    |
| HYPOLIMNION              | :The uniformly cold and deep layer of a lake lying below the thermocline, when the lake is thermally stratified. Diagram #1                                                                                                                                                                                                                                         |
| KJELDAHL NITROGEN        | :Sum of nitrogen present in the ammonia and organic forms (it does not include nitrite or nitrate).                                                                                                                                                                                                                                                                 |
| MESOTROPHIC              | :Waters characterized by a moderate nutrient supply and organic production (i.e. midway between eutrophic and oligotrophic).                                                                                                                                                                                                                                        |
| METALIMNION              | :See thermocline.                                                                                                                                                                                                                                                                                                                                                   |
| OLIGOTROPHIC             | :Waters containing a small nutrient supply and consequently characterized by a low rate of organic production.                                                                                                                                                                                                                                                      |
| pH                       | :Is the measure of the hydrogen ion concentration expressed as the negative logarithm of the molar concentration.                                                                                                                                                                                                                                                   |
| PHOSPHORUS (TOTAL)       | :Sum of all forms of phosphorus present in the sample.                                                                                                                                                                                                                                                                                                              |

## SECCHI DISC

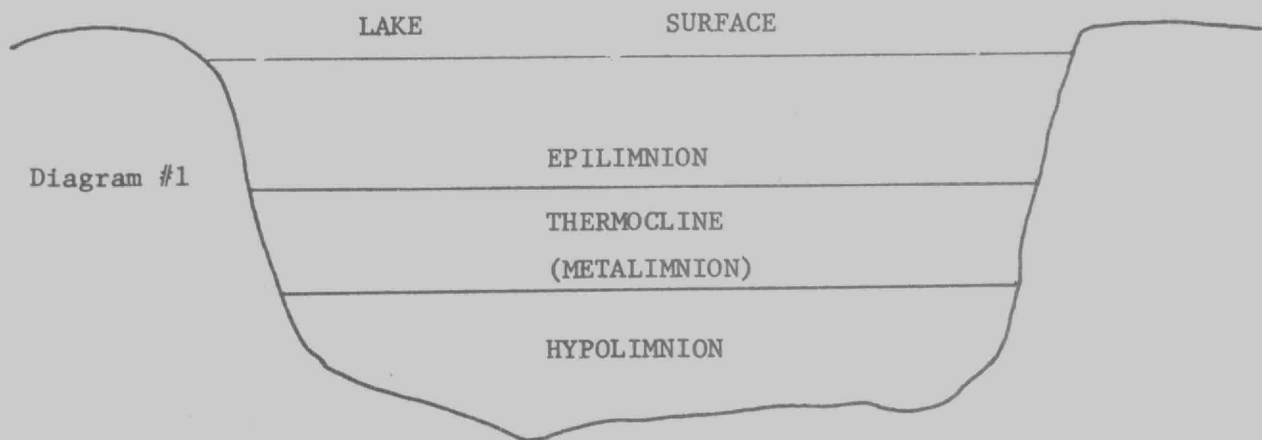
:A circular metal plate, 20 centimeters in diameter, the upper surface of which is divided into four equal quadrants. Two quadrants directly opposite each other are painted black and the intervening ones white. The secchi disc is used to estimate the turbidity of the lake water.

## THERMAL STRATIFICATION

:During the spring, vertical temperatures in a lake are homogeneous from top to bottom. As summer advances, the surface waters become warmer and less dense than the underlying cooler waters. A strong thermal gradient (Thermocline) occurs giving rise to three distinct water layers. The variation in density between layers retards mixing by wind action and water currents. Diagram #1.

## THERMOCLINE (metalimnion)

:The layer of water located between the epilimnion and hypolimnion in which the temperature exhibits a decline equal to or exceeding  $1^{\circ}\text{C}$  increase per meter.



## TOTAL COLIFORMS (TC)

:Total coliforms are bacteria commonly associated with fecal pollution but may also be present naturally in the environment.

## TROPHIC STATUS

:Depending upon the degree of nutrient enrichment and resulting biological productivity, lakes are classified into three intergrading types:

TROPHIC STATUS  
(continued)

:oligotrophic, mesotrophic and eutrophic.

If the supply of nutrients to an oligotrophic lake is progressively increased, the lake will become more mesotrophic in character and with continued enrichment it will become eutrophic.



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### Microbiological Criteria

Water used for body contact recreational  
activities should be free from pathogens  
including any bacteria, fungi or viruses that  
may produce enteric disorders or eye, ear,  
nose, throat and skin infections. Where  
ingestion is probable, recreational waters  
can be considered impaired when the coliform,  
fecal coliform, and/or enterococcus geometric  
mean density exceeds 1000, 100 and/or 20  
per 100 ml respectively, in a series of at  
least 10 samples per month, including samples  
collected during weekend periods.

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